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A discourse on education & industry

Manchester

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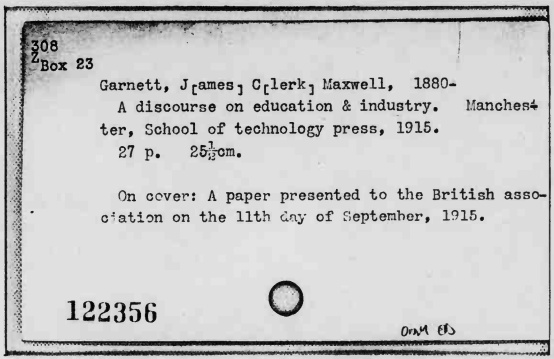

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EDUCATION & INDUSTRY

By J. C. MAXWELL GARNETT

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A PAPER PRESENTED TO THE
BRITISH ASSOCIATION ON THE
11TH DAY OF SEPTEMBER, 1915

A DISCOURSE ON

EDUCATION & INDUSTRY

by

J. C. MAXWELL GARNETT, M.A.
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of Manchester.

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1915

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I.

IN the old time before the war it used to be supposed that the administration of anything under Government—whether Admiralty, or Trade, or Education, or India—required no special training whatever. I was then surprised to find a junior administrator of education reading Dr. Sadler's book on "Continuation Schools." I said, "That is a good book." He said, "Yes, but Sadler sometimes writes as if education might be a science; there, of course, he is wrong." I replied that, in my opinion, Sadler was right; and that in any case we must so think of education if we wished to make progress. He answered, "Plato disagrees with you." And there the matter ended.

The British Association by establishing Section L recognised education as a branch of science, and made provision for its advancement. Meanwhile, however, the popular view agrees with that of my Platonic friend. Education—I am speaking of that part of it in which human educators intervene—is still regarded as belonging to politics and literature rather than to physiology and economics. To many people the very title of this paper —"Education and Industry"—will appear incongruous. Is there not a great gulf fixed, say they, between hazy views of education high in the clouds above and the hard facts of science or technology far in the depths beneath? And yet the intimate relation of education to industry is obvious enough. Of all that goes to make industry possible, let alone prosperous, the human element is the most important. We are careful to select suitable land, we know that capital or credit is essential to us, and we take pains to see that our capital is represented by the most suitable works, machinery, and material. But we commonly take little interest in producing the necessary men to undertake, design, direct or manipulate the work.

It is true that industry exists for men, not men for industry; and it follows that to train men for industry cannot be the whole end of education. How far the specific training of men for their particular occupations is legitimate can only be decided when we know what the true aim of education really is. Upon the answer to this fundamental question educators are not agreed.

But agreement should not be altogether out of reach if only we would treat education as a natural science. We should then endeavour to keep our thought about education in the closest possible touch with facts, especially physiological facts; we should think and speak, not only of the mind or soul, but also of the cortex of the cerebrum through which alone the soul can be reached by human educators. When facts are available we should use them and follow George Eliot's advice not to replace them by metaphors, or mixed metaphors like that of the broad foundation of general culture. When facts are not available we should, if possible, ascertain them by direct experiment and, if that is not possible, we should have faith: that is, we should ascertain the facts indirectly by acting on an hypothesis with a view to its verification or modification by subsequent experience. That is how progress has been made in other branches of knowledge, and that is how the advancement of the science of education must also be effected. Moreover, the ground so won must be consolidated by the use of some esoteric or symbolic language, for at present our most precise conceptions, being expressed in words that are used every day with many different meanings, receive from each of our hearers or readers a different interpretation.

Consider, for example, the word "character." Perhaps the most generally accepted statement of the aim of education is that of the opening sentence of the Introduction to the Public Elementary School Code: "The purpose . . . is to form and strengthen the character. . . ." But this statement fails to convey any clear conception because it does not define "character," a word which means different things to different people, and which to most people, perhaps, conveys no clear meaning at all. If,

however, we reflect that since two men who when placed in the same circumstances always did the same thing would, for practical purposes, be indistinguishable, we realise that men are characterised by their actions: by their fruits they are known. If then we enquire what it is that determines an individual's actions we find (as I have attempted to show in a recent paper[1]) that, in addition to the sensory stimuli arising from the environment of the moment, the determining factors are Interest, Instinct, and Will, together with the Habits they have helped to form. These then are the foundations of character. A further enquiry shews that, if character is to be strong, two conditions must be fulfilled: in the first place, interest must be single and wide, combining the whole range of the individual's experience into one group of inter-associated ideas and including central ideas which strongly move the emotions (instincts); and, secondly, the will must co-operate with this single wide interest and its central group of instincts in guiding thought and action.

It follows that, if the purpose of education is to form and strengthen character, the proximate aim of education must be to develop a single wide interest.[2]

If the citizens we are educating are to have characters that are not only strong but also good—that is, if each citizen is to be anxious to serve his neighbours—the emotional element at the heart of his wide interest must be rich in brotherly love. Education without religion is impossible.

If the individual citizens are to be not only anxious, but also able, to serve each other they must be prepared to divide labour among themselves so as to minister to the economic wellbeing of the community. The more a man's knowledge or skill differs from that of other people the better in general can he serve his fellow men. As the occupations of different individuals must differ and as all

[1] Published in "Manual Training" for May, 1915.

[2] This single wide interest might be called by Dr. Morton Prince "a single complex of closely related neurograms"; by Mr. A. F. Shand "a single all-embracing sentiment"; and by Dr. McDougall "an intimately inter-related system of sentiments centred about the self-regarding sentiment."

the ideas that come to each in the course of his daily work are to form part of his single wide interest, it follows that the single wide interests of different individuals must differ according to their different occupations; and the great interest which each man will then take in his work will incidentally make for his economic efficiency. It is true that these single wide interests must also overlap, so that different individuals may share as far as possible each other's interests and have at least their interest in the State in common. The extent of this overlapping of interests should be limited only by the necessity of securing that, during the years immediately preceding the entry of the educand—Professor Adams' name for the person being educated—into a specialised occupation, the single wide interest in process of development shall include ideas with which the new vocational ideas will readily form associations: unless this is secured, the new vocational ideas will be in danger of forming a separate interest apart from the rest. It is clear, therefore, that during the last two or three years at school—or, if the educand proceeds to college, then during his university course—his education should have the *specific* aim of preparing him for his particular work in life, including not only the work for which he is paid but the whole of what Kim would call his "Great Game." The same conclusion —which is no more than the application to education of the principle of continuity, so familiar in other branches of natural science—has been thus expressed by the Board of Education's Consultative Committee: "The nearer a pupil is to his entrance into life, the more steadily must the actual practical needs of his occupation be kept in view and the more decided therefore must be the bent of his education to that end."[1]

Finally, education must train the will. The power of the will to focus attention—to direct nerve impulses into a particular system of nervous arcs—is the supreme intellectual faculty, and the only faculty that can be trained. Whoever is to have most creative or abstract thinking to do, most needs this skill in thinking.

[1] Report on Higher Elementary Schools, 1906, p. 11.

II.

These conclusions have been separately proclaimed by several high authorities.

"Milton," said Professor Perry last year from the presidential chair of Section L, "taught me the true notion of education, that the greatest mistake is in teaching subjects in water-tight compartments."[1] In fact, education must aim at building up a *single* wide interest.

"Thorough knowledge of one subject and practice in it," said Goethe, "produces higher culture than incomplete knowledge of a hundred subjects."[2]

Ruskin had no doubt about the need for specific education. "The idea," he wrote, "of a general education that is to fit everybody to be Emperor of Russia . . . is the most entirely and directly diabolical of all the countless stupidities into which the British nation has of late been betrayed."[3]

"The most fatal demand which the higher schools have ever had to face is," according to Dr. Kerschensteiner, "the demand for general, all-round education."[4]

"The whole evolution of educational theory," according to Professor Adams, "may be said to be a great sweep from specific education back to specific education, through a long period during which formal training held the field."[5]

Finally, William James maintained that "the faculty of voluntarily bringing back a wandering attention over and over again, is the very root of judgment, character, and will. No one is *compos sui* if he have it not. An education which should improve this faculty would be the education *par excellence*."[6]

[1] "Nature," 1st October, 1914.
[2] Quoted by Dr. Kerschensteiner, "Schools and the Nation," p. 256.
[3] "Fors Clavigera," p. 254.
[4] *Loc. cit.*, p. 255.
[5] "Evolution of Educational Theory," p. 225.
[6] "Principles of Psychology," vol. ii., p. 124.

III.

We shall now assume the truth of these conclusions and proceed to discuss the problem of so educating every individual that he shall possess, in the first place, the single wide interest which his particular service to the community most needs for its efficiency, and, secondly, skill in thinking—the capacity of voluntarily focussing his attention.

Any attempt to decide beforehand, and without regard to their natural abilities, what positions particular children were to occupy when grown up, and to educate them accordingly, would probably meet with disaster; but it is by no means certain that this disaster would be greater than that which attends the present practice of educating without regard to future occupation.

It is, however, quite another matter first to investigate the qualities—the type of single wide interest and the degree of skill in thinking—required by those who are to occupy the various positions in industry, commerce, and other departments of national life; and afterwards to indicate a means of developing the required qualities in a sufficient number of persons, selected on account of their innate aptitudes for each different kind of work. We shall reduce the magnitude of this problem by confining our attention to the qualities, and to the means of providing the qualities, required in *industrial* occupations. Even so, however, we shall not have time separately to consider every such occupation, but only certain *classes* of occupations.

The first classification to suggest itself is that of the various branches of industry, such as engineering, building, chemical manufacture, the textile industry, and the like. But the qualities required in the manager of an engineering works have more in common with those needed by the manager of a chemical works or of a cotton mill than with the qualities sought for in the lowest grades

of labour employed in any of these industries. In the same way the designer of electrical machinery will generally have less in common with the engineering tradesman who makes what he designs, than with the professional physicist who would never be classed as an engineer.

We shall find it convenient to adopt the following classification :—

Class A.—Industrial statesmen; chief designers; research engineers, research chemists, etc.; consulting engineers, etc.

Class B.—Works managers and heads of departments; junior members of designing, testing, and managerial staff.

Class C.—Foremen and leading hands; skilled tradesmen.

Class D.—Machinemen and repetition workers; unskilled labourers.

No essential discontinuities are to be imagined between these classes; nor are the occupations named to be regarded as forming a complete list of the classes of work they are intended to indicate.

We have already remarked that every occupation includes that of citizen, so that different citizens must, as far as possible, share one another's interests. We have next to consider the special or distinguishing features of each type of occupation.

It is clear that each class is concerned, in the course of daily work, with a greater *variety* of ideas than the class next below it. Accordingly trains of thought of members of class A must on the average be fresher, and therefore less governed by habit, than those of members of classes B, C or D. "The controllers of the great industry," writes Mr. Graham Wallas, "are always on the look out for that type of man whom Americans call 'a live wire.' For such a man secretaries and typists and foremen carry on all that punctual performance of habitual acts which took up so much of the time and labour of a merchant or

manufacturer even fifty years ago. He is set to form a habit of non-habituation."[1] Such a man requires more emotional drive than one who is engaged in mere routine work. And since his ideas cover so wide a range, they are not so naturally associated together as those which their daily work brings to members of classes B or C or D. He therefore needs to weld his various ideas into a single wide interest by making voluntary associations between them; and in order to make such associations, especially between dissimilar ideas, he needs skill in thinking. So then class A requires a wider interest and more skill in thinking—*but not necessarily more pay*—than class B, class B than class C, and class C than class D.

Let us now look more closely at each of these classes. The first named on our list is that of the industrial statesman. We know him already as the captain of industry. But he may shortly change his name, for the title of captain does not indicate with sufficient clearness the fact that the head of a great industrial firm must needs concern himself with much that is happening outside the establishments which he controls. Not only must he be familiar with the state of the markets from which he draws his supplies and in which he disposes of his products, but, by grasping the significance of economic, social and political changes all over the world, he must be able to foresee opportunities for developing his business according to a far-reaching policy and to indicate the lines of technological research which are most likely to lead to such developments. Work of this kind involves the widest sort of knowledge. But *beware of the professional administrator who is prepared to administer anything at a moment's notice!* The statesman—whether industrial or not—must possess, in addition to a wide range of knowledge and much skill in thinking, a very special interest in the particular concern he is directing, whether that concern is his own small business or an Empire whose destinies are under his control. He must see that concern as a whole, and must love it. "Without passion," said Lord

[1] "The Great Society," p. 87.

Haldane to the students of Edinburgh University, "nothing great is, or ever has been, accomplished."[1]

Lord Haldane went on to compare the statesman with the expert, greatly to the latter's disadvantage. Much that has happened lately would probably cause Lord Haldane to express himself differently now. In any case we shall not follow him here. We shall instead place the expert in the same class as the industrial statesman because the former requires an equally high degree of skill in thinking and at least as complex (if not so widely varied or so emotional) an interest as the latter. The industrial statesman may perhaps be compared to the astronomer who uses his telescope to increase his grasp of the universe as a whole, while the expert rather resembles the naturalist whose microscope enables him to see the parts in great detail. It is evident that the successful development of industry demands not only the expert in special branches of science or technology (even in so narrow a field as that of the methyl-blue chemist whom Lord Moulton recently described[2]), but also the industrial statesman who co-ordinates the work of experts in different fields, being himself enough of a specialist fully to understand his experts, to command their confidence, and, when necessary, to decide between them. Whoever has authority must also have knowledge.

The members of class B require fewer associations to connect the ideas which constitute their single wide interests. Their knowledge of mathematics, for example, need only include what is commonly used, or is likely to be used, in the routine of their daily duties: they must be able to *follow* a paper on some subject connected with their work, but need not have had enough practice in the *use* of mathematics to employ it freely upon investigations originated by themselves. They need less skill in thinking than members of class A. They require, on the other hand, a very wide descriptive knowledge of material things; and as much of this knowledge as possible they

[1] "The Conduct of Life," p. 25.
[2] Journal of the Society of Dyers and Colourists, vol. xxxi., p. 10, 1915.

should have acquired at first hand from direct sense impressions. Last, but by no means least, the works manager and his immediate assistants need to interest themselves in the social and economic welfare—including the further education, recreation, and housing—of all their employees; and this interest will help to form the nuclei of the single wide interests which are to include all the activities of members of class B.

Foremen and leading hands have hitherto been generally recruited from among skilled tradesmen. They are therefore presumed to be qualified themselves to perform every task they have to supervise, and even to perform it better than the men who are actually doing the work. Upon this presumption is based the claim that the shop foreman must be paid a higher wage than any workman under him. This view, accepted as it generally is by employers and employed alike, is responsible for no small restriction of output. But it is based on a misconception, since the foreman is paid for supervising men and the workman for manipulating material—two quite incommensurate processes. There are, however, signs of change. Technically trained foremen, whose wages may (to start with) be much less than those of the men they have to look after, are already being employed, especially in shops where much repetition work is done. Yet it remains true that the qualities now most sought for in foremen and leading hands are those of the craftsman whose interest is centred in his manual work.

The operative skilled tradesman, whom, for this reason, we have placed in the same class as his foreman, is distinguished from the machine man in class D in that the operative in class C has a *variety* of skilled work to do, while the members of class D, who may do skilled work, *repeat* the same process over and over again until its performance is governed by habit, when it almost ceases to receive attention. On the one hand ideas connected with *doing*, like ideas associated with a strong instinct, are peculiarly liable to receive attention, so that the work of the skilled tradesman in class C is well able to form a

strong centre for his single wide interest. On the other hand ideas connected with the repetition work of class D tend to become circumscribed and cut off from other interests. There is, however, reason to believe that repetition work is not altogether uninteresting to a certain type of mind. It is indeed actually preferred by some people, including many women; so that such work may form a substantial, if not a dominant, part of an interest that is not rich in exciting ideas.

The remaining part of the single wide interest is of special importance in the case of class D. When an eight-hours day is universal it may be that the artisan or labourer, who leaves work with much of his day still before him and feeling pleasantly exercised rather than unduly tired by his somewhat montonous but by no means exacting labour, will devote himself increasingly to national and municipal affairs. With that end in view we must see to it that the average member of class D receives—not only in maturity through the Workers' Educational Association, but also in youth through vocational part-time classes—the kind of training which shall best develop a single interest, wide enough to include the highest ideals of patriotism as well as loyalty to a particular industrial class.

IV.

We have next to consider how to develop in a sufficient number of suitably selected persons the qualities which we have indicated as specially needed in each class of industrial occupation.

Childhood up to, say, twelve years of age has few organised interests. Accordingly the need for a coherent curriculum, aiming at developing a single wide interest, does not obtrude itself until adolescence begins.

The future member of classes A and B will normally spend much of his adolescence in a secondary school. Of these schools it is convenient to distinguish two types, named "Higher" and "Lower" respectively in the accompanying diagram.

The chief function of the secondary school, the school for adolescents, is to foster the growth of true religion—"not theology nor yet ethics, but personal and experimental"[1]—and around this centre to build up, out of the miscellaneous information obtained in childhood and the coherent curriculum which the secondary school should itself provide, the beginnings of that single wide interest which should continue to grow throughout maturity. The skill in thinking which the secondary school must also cultivate is best practised upon a number of closely associated ideas—a coherent interest—because, unless the idea before consciousness at any moment calls up *many* others from which the will can select that which is next to receive attention, this faculty cannot be practised; and without practice skill in thinking cannot be developed.

The broad foundation metaphor, of which Dr. Kerschensteiner[2] has made such fine fun, is probably responsible for the fact that most secondary schools aim in theory, and some lower secondary schools (unfortunately) in practice also, at comprehensiveness rather than at

[1] G. Stanley Hall, "Adolescence," vol. ii., p. 326.
[2] "Schools and the Nation," p. 275.

coherence of interest; they have failed to realise that coherence at seventeen is the surest way to comprehensiveness at twenty-seven. Concentration has, however, been practised by the classical sides of English public schools. But in spite of the concentration of a classical form, which spends the greater part of the week upon closely associated subjects under its own form master, the Headmaster of Shrewsbury complains that the degree of coherence attained is not yet sufficient. "It is obvious," he writes, "that the ordinary public school curriculum is grossly overcrowded."[1] "When the Headmaster of Eton entered on his post," says Mr. Alington in another place, "he did me the honour to invite my advice. I told him that if he had any moral courage he ought certainly to abolish French. His answer was 'Now it is a most amazing fact, but I was told that by a really clever man only yesterday.'"[2] And yet in many of the newer secondary schools six or seven distinct subjects are taught out of all relation to one another by as many separate specialists, and the form master himself is almost unknown!

The future member of class A should remain at his higher secondary school and enter the university at, or soon after, the age of eighteen. It is true that the future engineer often spends some time in works between school and college; but there is a growing concensus of opinion that this period should not be too long. Perhaps from Christmas until the following October would be ideal if both school-leaving and university-entrance scholarships could be awarded, as those of some Oxford and Cambridge colleges already are, just before Christmas.

It is to the university that we shall principally look in the future for an essential part of the specific training of members of class A, for the men with creative minds, inventors of new appliances and processes, men who shall not merely be able to follow existing practice but also to cope with new problems and even to lead in new lines of advance. And our university courses, if they succeed in

[1] Rev. C. Alington, "A Schoolmaster's Apology," p. 35.
[2] *Loc. cit*, p. 48.

producing men of this type, will do so, not because of the knowledge they impart, wide though it be, but because of the stress they lay on the acquisition of skill in thinking along with knowledge. It is skill in thinking—skill in applying old knowledge to new situations—rather than knowledge itself without such skill, that now, as always, marks the really practical man. If, in fact, his university course can, in Huxley's phrase, give him "real, precise, thorough and practical knowledge of fundamentals," the candidate for membership of class A may well wait for subsequent works experience, post-graduate evening classes, and private reading, to develop further his *technical* information to a marketable standard. Whatever letters he may be able to write after his name, his undergraduate course should have aimed at making him a Bachelor of Arts, skilled in the art of learning, and only incidentally have given him a body of scientific knowledge capable of immediate application.

This view of the chief aim of a university course insists that there shall not be overmuch lecturing; that information shall be acquired because it is immediately and urgently needed for the solution of some practical problem; that a larger proportion of the most able students shall remain "up" after taking their degrees for the purpose of undertaking original research; and that, while the most distinguished professors shall take part in the teaching of the undergraduates from the outset, they shall do so, not because of the knowledge they are peculiarly able to impart, but because "the personal influence of the man doing original work in his subject inspires belief in it, awakens enthusiasm, and gains disciples."[1]

In urging that the chief aim of a university course must be to cultivate skill in thinking rather than to impart information, we do not mean that such a course must be at all detached from practical things. It is no more possible to develop skill in thinking without knowledge, than to acquire skill in the use of tools without material to work

[1] Final Report of the Royal Commission on University Education in London, p. 29.

upon. Technical knowledge is, in fact, a most excellent foundation and medium for cultivating skill in thinking.

England is fortunate in that, with one important exception, her highest study and research in technology form part of the work of her universities. For a university is more than a university course or an aggregate of such courses. The opportunities which a university affords for studying elective subjects are important. But far more important is the intimate and constant association in the various students' societies, as well as in the lecture rooms, drawing offices, or laboratories, between students in different Faculties, from different countries, and with entirely different outlooks. Newman, writing in 1852, even went so far as to say :—

> "I protest to you, gentlemen, that if I had to choose between a so-called University, which dispensed with residence and tutorial superintendence, and gave its degrees to any person who passed an examination in a wide range of subjects, and a University which had no professors or examinations at all, but merely brought a number of young men together for three or four years, and then sent them away again as the University of Oxford is said to have done some sixty years since, if I were asked which of these two methods was the better discipline of the intellect . . . which of the two courses was the more successful in training, moulding, enlarging the mind, which sent out men the more fitted for their secular duties, which produced better public men, men of the world, men whose names would descend to posterity, I have no hesitation in giving the preference to that University which did nothing, over that which exacted of its members an acquaintance with every science under the sun."[1]

To the technical knowledge which the future member of class A has acquired at his university, he should go on adding during his post-graduate training in the works, and, indeed, so long as his industrial life continues. Much

[1] Quoted in the Final Report of the Royal Commission on University Education in London, pp. 26 and 27.

of this additional knowledge he will acquire in his daily employment. But he should also attend post-graduate evening classes from time to time. So will he keep up to date his knowledge of new advances outside his own particular line. And, if he is able to attend such classes taken by his own former professors, his attendance will benefit his university as well as himself. For the professors and lecturers who take these advanced classes find that evening students who are engaged all day in industrial practice are hardly less effective than their own consulting work in keeping them abreast of the most recent industrial developments.

The State cannot afford to provide a university training for all its citizens. The majority, even of class B, will be compelled, by economic pressure, to begin earning money before they are twenty years old. Where a suitable "Senior Technical School" exists, they will do well to receive in it the specific training which should occupy the last two years before their entry into industrial life. The very important place which a senior technical school should fill in the educational system of an industrial district is, as yet, hardly realised.

The future member of class C should be transferred from the public elementary school to the "Junior Technical School" when other children are transferred to the lower secondary school. The junior technical school should prepare him for entering one of a group of allied trades at, or about, the age of fifteen. It is not, however, the function of the junior technical school to teach him a trade, but rather to develop his manual skill in work that is closely related to that of the trade to which he is looking forward, and to extend the great interest which he cannot help feeling in such work so as also to include so-called "general" subjects. Experience has shewn that he will thus make more progress in these "general" subjects than if he were studying them in a school which had no specific aim.

When the future members of classes A, B and C have been transferred from the public elementary schools at

about the age of twelve, the work of the future members of class D who are left behind should differ[1] somewhat from the general work done by all children below that age. It might well be centred in (but not, of course, be confined to) handwork during these last two years, and so have much in common with the training of Boy Scouts.

Even when the last two years of whole-time education have been admirably adapted to prepare the educand for his imminent vocation, some educational discontinuity must always occur as he leaves whole-time school or college to continue his education in industrial life. Part-time classes afford the best means of reducing this discontinuity to a minimum. Accordingly, every boy or man, as he first enters upon industrial work, should attend suitable part-time classes. No feature of English education is more striking to the foreign observer than the system of part-time courses in all our great centres of industry. At present most part-time courses ("Major Courses") involve attendance on three evenings a week for several successive years. Although they cannot cover the whole ground of university courses, they aim for the most part at affording an alternative means of training men to occupy positions of responsibility in industrial affairs.

While, however, our part-time classes are thus training technical men, they are neglecting manual workers. Instead of attending these technical classes, the boy who enters works at fourteen or fifteen years of age requires (at least until he is seventeen years old) a special type of part-time course to which the name "Minor Course" has lately been given. One of the principal objects of such a course is to provide instruction in those matters which the trade apprentice in bygone days learned by close association with a master craftsman, and which are commonly lost to him under modern industrial conditions. The minor course will therefore "have as its central subject the trade processes or craft in which the students are engaged."[2]

[1] This differentiation is indicated by the dotted line at γ in the diagram.
[2] Board of Education Circular 894.

But so-called "citizenship" subjects—such as history and economics, the study of which will make for a better understanding of problems concerning wages and hours of labour—also form an essential part of a minor course. It remains to add that the need for minor courses is not yet sufficiently appreciated, with the result that a great opportunity of educating during the critical years of adolescence the numerous members of class C and class D is being neglected.

V.

The system of education, the outline of which I have just described, is represented on paper in the accompanying diagram. Its realisation in any English industrial district—Manchester, for example—would need some, but not much, co-ordination; for the diagram represents neither what is nor what might be under ideal conditions, but what could be made out of what is with the maximum of advantage for the effort required to make the change. The co-operation of local education authorities, universities, the Government, employers, and parents would be required in order to complete this change.

But already there are signs that all the necessary co-operation is forthcoming. Many striking instances might be cited in support of this statement did time permit. I must, however, be content to mention only two:—Mr. Henderson's new scheme for the organisation and development of industrial research; and a similar scheme recently prepared by a committee of the Manchester Engineers' Club. This latter scheme provides for organised co-operation between schools, colleges, and engineering firms in the education of engineers, as well as for the encouragement of research in the following among other ways:—

By developing co-operation between engineering firms on the one hand and Universities and Technical Colleges on the other, so as to establish such "Schools of Thought" as exist in the research departments of great Continental and American engineering firms, but cannot be fostered in the comparatively small establishments (and smaller research departments) of most British engineering firms.

VI.

The co-ordinated system of schools, colleges, and works represented in the diagram will not be satisfactory unless it is thoroughly democratic. It is true that innate differences between individuals cannot well be distinguished from differences produced by home surroundings. But whoever is best fitted by nature and nurture for any particular class of occupation should be selected to receive, if necessary at the State's expense, the training which will best prepare him for it. Education Authorities should see that the number of persons so selected is sufficient—but not much more than sufficient—to supply whatever demand is also a need.

At present the supply of men for the highest classes of work falls very far short of the demand. Every year the number of appointments offered to School of Technology graduates greatly exceeds the number of these graduates. Not only is this true of posts in chemical works, but also of electrical and other engineering appointments. Although the number of undergraduates in the School of Technology (Faculty of Technology in Manchester University) increased by fifty per cent in the two years before the war, the demand for their services after graduation increased in a still larger proportion.

The development of this demand may be well illustrated by the case of engineers. It is not many years since the raw graduate in engineering who was without works experience had to pay a heavy premium, even in Manchester, in order to be allowed to complete his engineering training in a works. But for some years past most of the leading engineering firms in this district have paid such graduates at an average rate of between ten and twenty shillings a week during their two years of college-apprenticeship immediately following their graduation. This year, however, two of the largest engineering firms have followed the example, set by chemical manufacturers in this country and by engineering firms in America, of offering a living wage to graduates before they have had any industrial experience.

Such facts as these need to be realised by boys and by their parents. But it is even more important that they should realise that the highest kind of technological work is noble work, worthy of a lifetime's duration. The profession of applying science to industry is rich in opportunities for helping to bring about the ideal future of the human race. While it is the glory of the medical profession, for example, that it assists in preventing a wastage of life that could not but retard human progress, we must remember that technology helps to produce what medicine and surgery help to preserve. The great increase in population which began in the middle of the eighteenth century was directly due to mechanical invention. Indeed, the application of science to industry not only renders possible a rapid growth of population, but it exempts an ever-growing proportion of this increasing population from the need for incessant physical toil. Moreover, all that acceleration of human progress which results from the increasing national expenditure on the education of the people, would cease with any interruption of the march of technological invention.

Every improvement, then, which the technologist may be able to make in the direction of cheapening production —reducing, for example, the cost of a brake horse-power-hour—will help to increase the number of men whom the community can spare for the study of classical literature in order to keep the thought of our time in touch with the best of the thought of ancient Greece and Rome; it will help to increase, too, the number of those who can be spared by this generation to devote their lives to scientific research, to widen the scope of human thought, to teach men more of the works and ways of God, and to obtain the knowledge which technologists of the future will apply for the benefit of generations not yet born; and, most important of all, it will help to support the seers and the prophets on whom we so largely depend in the weightiest affairs of human life.

APPENDIX.

The diagram which accompanies this paper does not represent the present organisation of the education of persons who will spend their lives in various grades of industrial work. Nor does it shew an ideal organisation out of all relation to existing schools, colleges, and works. The diagram is rather intended to show that organisation which might be created out of what exists at present with a minimum expenditure of effort in proportion to the advantage secured by the change.

The figures on the bottom line—the age-axis—of the diagram represent ages. The diagram is thus confined to the education of persons between the ages of 10 and 27 who at the age of, say, 40 will be employed in various grades of industrial occupations.

The unhatched portion of the diagram is concerned with "full-time" education: that is, with schools and classes meeting in the daytime and occupying all the working hours of those by whom they are attended. The central singly-hatched area relates to part-time classes: classes meeting in the day or in the evening and intended for persons whose employment occupies the greater part of their time. The doubly-hatched region on the right of the diagram corresponds to those later years of industrial practice when a man has ceased to attend organised courses of study bearing upon his trade or profession.

The unhatched part is divided into separate areas which correspond to the following types of school:—

1. The Public Elementary School.
2. The Junior Technical School (see page 18) taking boys from about 12 to 15.
3. The Lower Secondary School, which receives most of its boys from the Public Elementary Schools with scholarships or free places at about the age of 12 and retains only a small proportion beyond the age of 16.
4. The Senior Technical School (see page 18) which provides a two-years course for boys between 16 and 18.
5. The Private Preparatory School, a boarding or day school which prepares boys to enter Public Schools and other Higher Secondary Schools between 13 and 14.

6. The Higher Secondary School, which takes most of its boys from Private Preparatory Schools at 13 or 14, and retains the majority until 18 or 19, when many of them proceed to a University, or Technical College of university rank.
7. University Courses which are pursued, chiefly by young men who enter direct from Higher Secondary Schools between 17 and 19 years of age, but also by other students who are mostly more mature and have spent some years in full-time employment since leaving school. University Courses generally retain their students for at least three or four years, and the more brilliant students often remain for several years longer engaged in research work.

The central singly-hatched area is divided by *dotted* (instead of continuous) lines in order to indicate that the various part-time courses, many of which are commonly conducted in the same building, are not so clearly separated from each other as are the different types of day school or college. The part-time courses shown include the following:—

1. Minor Courses[1] (see page 19): intended for boys, between 14 and 17 or 18 years of age, who aim at permanent employment in some skilled trade.
2. The Junior Course: a general course in drawing, mathematics, science and English, preparing a comparatively small number of boys between 14 and 16 years of age to enter Senior Courses at 16 years of age.
3. Major Courses (see page 19): extending over five years and divided into two parts—the Senior Course and the Advanced Course.
4. Post-graduate and other special classes, where *inter alia*, "those who have passed the ordinary educational age may modernise their ideas and enlarge their outlook."

The distance between each pair of adjacent vertical lines in the diagram represents one year. While the diagram is thus drawn to scale from left to right, it is not drawn to scale from bottom to top. But in each separately enclosed area, corresponding to a par-

[1] The Minor Course here proposed differs from that defined in the Board of Education's "Memorandum on the Teaching of Engineering in Evening Technical Schools" (Circular 894), in that the former begins as soon as the boys leave their day schools to enter engineering trades, while the latter begins two years later. The only sufficient reason for postponing the beginning of a Minor Course until two years after the day school has been left would be that boys do not in fact enter upon their trade apprenticeship until two years after leaving school. But such a two years' interval is altogether bad. The scheme here proposed therefore provides for boys to remain in full time attendance at school until they enter upon their trade apprenticeship. See "Nature," 22nd April, 1915.

ticular course of study, the intercept on any ordinate (or line drawn perpendicular to the age-axis) is greater or less according as the number of students of the corresponding age who should be following the course in question is greater or less; but the intercepts are not strictly proportional to these numbers. This correspondence does not, however, hold of intercepts in *different* enclosed areas.

In order to make the diagram as simple as possible the beginnings and ends of courses have been represented by lines perpendicular to the age-axis, except in a few cases—*e.g.*, the beginning of the Higher Secondary School, the end of University Courses, and the ends of Part-time Courses. It is not, however, to be supposed that (except as regards children who leave the Elementary School so soon as they have reached the age when compulsory school attendance ceases) students begin or complete their courses exactly on their birthdays. For example, children entering the Lower Secondary School or the Junior Technical School at about the age of 12 will vary in age from at least 11⅓ years to 12⅓ years, so that the entry line in the diagram should be straight with its centre on the 12 years ordinate and its ends on the 11⅓ years and 12⅓ years ordinates respectively. Similarly the entry line to University Courses should have one end on the 17 years ordinate and slope, with a maximum inclination to the age-axis at about the 18 years ordinate, until its other end rests outside the diagram altogether, indicating that the students admitted to a University in any year always include a few men of mature age.

Three types of arrow-heads have been employed in the diagram to indicate the relative numbers proceeding from any particular type of school to the school next above it. The triple head indicates that the great majority of the persons leaving from the school which corresponds to the area in which the arrow-head lies proceed to the course to which it points. The double-headed arrow means that there should be (if there is not already) a system of scholarships, bursaries or free places by means of which a regular supply of students is maintained from the lower to the higher school. The single arrow-head represents a few exceptional students being transferred from one school to another. The single, double or triple arrow in any closed area, wherever it appears, always represents approximately the same *proportion* of students transferred from the school corresponding to that area to the schools next above it; but the same type of arrow in different parts of the diagram does not represent, even approximately, the same absolute *numbers* of students transferred per annum. Thus the single arrow from Junior to Senior Part-time Courses will represent a larger number than the single arrow from the Junior Technical School to the Senior

Technical School; or again the triple arrow from the Senior Technical School to the Advanced Part-time Course may represent a smaller number than the double arrow from the Public Elementary School to the Lower Secondary School.

It will be observed that a boy who starts life in a Public Elementary School and crosses every educational boundary shown in the diagrams at a point marked with triple arrows will ultimately find himself in one of the lower ranks of labour to which the space in the bottom right-hand corner of the diagram corresponds. No other industrial employment is to be obtained except by crossing some boundary at a point marked by a double, or even by a single arrow; either of which represents the selection of the candidate who crosses from among a larger number who do not cross. The most desirable path to any of the positions shewn on the right-hand side of the diagram is found by following triple arrows rather than double, and double arrows rather than single.

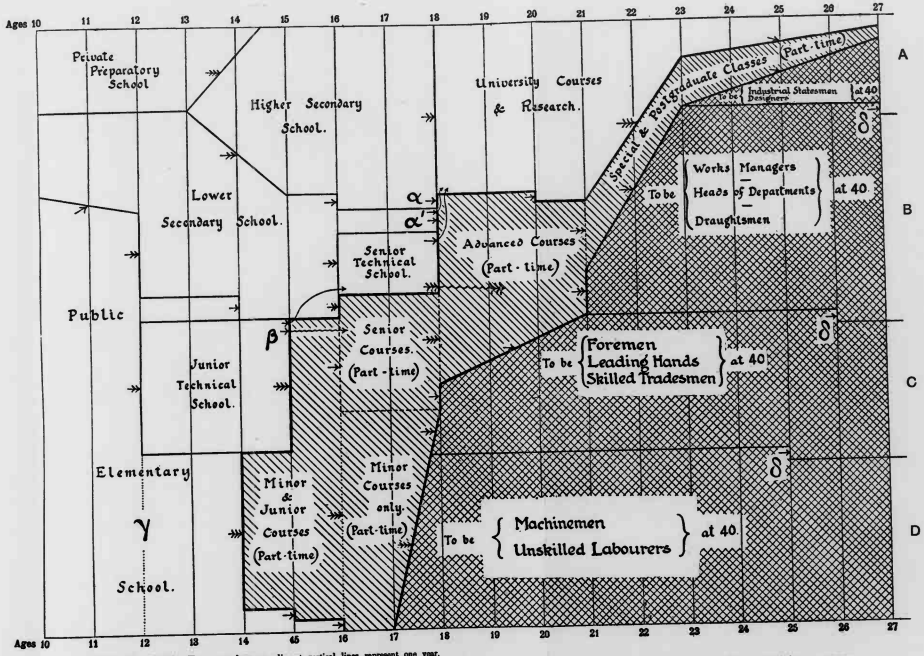
Students transferred from Secondary Schools to Part-time Courses at about the age of 18 (as indicated by the arrows at α and α') will not in general be admitted directly into advanced courses, but will have first to spend some time in special courses in which they will study the technical subjects which other entrants to Advanced Part-time Courses have studied in the Senior Technical School or in Senior Part-time Courses.

For simplicity, the diagram shows almost all boys who proceed from secondary schools to University Courses as proceeding directly from school to college and obtaining their works experience after graduation.

The single arrow at β indicates that only a small proportion of Junior Technical School boys should proceed directly to Senior Part-time Courses. The majority of the students leaving Junior Technical Schools should attend Minor Courses in the daytime during the early years of their apprenticeship to skilled trades. The dotted line at γ is explained in the footnote on page 19.

The lines dividing the double-shaded area into separate sections are broken at the points marked δ in order to indicate that promotion from the rank of labourer to that of general manager is not *wholly* dependent upon school and college education, whether full-time or part-time. The points δ might be indefinitely multiplied.

Manchester: The Printing and Photographic
Technology Department of the School of
Technology.


Ages 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Private Preparatory School
Higher Secondary School.
University Courses & Research.
Special & Post-graduate Classes (Part-time)
To be Industrial Statesmen Designers at 40
A
Lower Secondary School.
α
α'
Senior Technical School.
Advanced Courses (Part-time)
δ
To be Works Managers — Heads of Departments — Draughtsmen at 40
B
Public
β
Senior Courses. (Part-time)
Junior Technical School.
To be Foremen Leading Hands Skilled Tradesmen at 40
δ
C
Elementary
γ
School.
Minor & Junior Courses (Part-time)
Minor Courses only (Part-time)
δ
To be Machinemen Unskilled Labourers at 40
D
Ages 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27

HORIZONTAL SCALE: The spaces between adjacent vertical lines represent one year.

VERTICAL SCALE: The vertical scale increases from the bottom of the diagram to the top. The intercept made on any ordinate by the enclosed area which corresponds to any course varies with (but not strictly in proportion to) the number of students of the corresponding age who should be following the course in question.

⇒ / → / → indicates that {the great majority of the / a constant supply of systematically selected / a few exceptional} persons leaving the course which corresponds to the area in which the arrow-head lies should proceed to the course towards which it points.

For further explanation of diagram see appendix.

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